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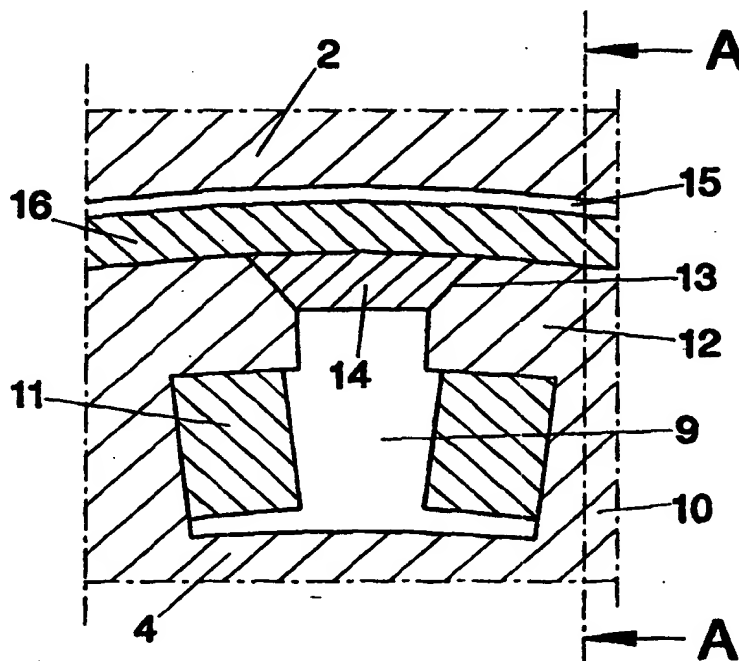
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(54) Title: AXIAL COOLING OF A ROTOR

(57) Abstract

A rotating electric machine (1) having a stator (2) provided with windings and a rotor (4) provided with field windings and with salient poles (10) forming pole gaps (9) between the pole shoes (12) of the poles (10), which rotor (4) is arranged to be cooled by air flowing axially through the pole gaps (9) of the rotor (4), wherein each pole gap (9) between the pole shoes (12) is covered by at least one covering member (14) and that the air gap (15) is equipped with a sealing ring (16) to limit axial air flow.



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Axial cooling of a rotor

TECHNICAL FIELD:

5 The present invention relates to large rotating electrical machines equipped with salient pole rotors such as synchronous motors used in industry and synchronous generators used in hydro power plants. The invention relates particularly to a design for controlling the cooling air flow in the rotor by choking the air flow in the air gap and sealing the gaps between adjacent poles.

10 BACKGROUND ART:

Synchronous machines with salient pole rotors are normally cooled with air. Large such machines have radial cooling ducts in the stator. The air is delivered to the stator ducts by first passing axially through the pole gaps in the rotor. In the pole gaps, the air passes axially along the field windings, thereby cooling them. The
15 relatively high peripheral speed of the rotor causes ventilation losses which consist partly of air gap friction losses and partly of a component which is proportional to the mass flow of air.

In order to minimize the ventilation losses it has been suggested in U.S. pat. No.
20 3,157,806 that the field winding be water cooled and the pole gaps completely filled with non-magnetic filling compound or enclosed by sealing members. This has the advantage of making the rotor surface smooth and cylindrical which reduces air gap friction. Several hydro generators have been built according to this concept and are described in "Fully water-cooled 190 MVA generators in the
25 Tonstad hydroelectric power station", Brown Boveri Review, (1969) 8, p 380-385. In this concept both the stator and rotor are water-cooled which means that the mass flow of air through the air gap can be minimal, thus reducing ventilation losses even more. However, water cooling is expensive and technically complex, especially in the rotor. For this reason it is advantageous if the rotor is air-cooled
30 while maintaining a cylindrical rotor surface. In U.S. Pat. 4,274,027 it is suggested to seal the gaps between adjacent poles but to leave openings at opposite ends of the pole gaps, obviously for axial air cooling of the field windings. However, it is not further described how the machine is cooled. Assuming that the stator is water-cooled, a drawback with this construction is that in the air gap between the
35 stator and the rotor, an air flow will pass that serves no purpose, it only contributes to the ventilation losses.

OBJECT OF THE INVENTION:

The object of the invention is to provide air flow control by an air seal placed in the air gap between stator and rotor. The device reduces the mass flow of air that enters axially into the air gap. Used in conjunction with pole gap seals this will
5 reduce the ventilation losses. Advantageous further developments of the invention are indicated in the following description.

SUMMARY OF THE INVENTION:

10 The present invention applies to a machine with a stator without radial ventilation ducts, e.g. water-cooled, and air-cooled rotor in which the pole gaps of the rotor are covered, thereby also blocking the entrance to the air gap on the fan side so that a larger amount of air from a rotor fan supplying the air gap of the rotor, is blown into the pole gaps. This means that a lower flow volume is required than if
15 the air is divided into one air flow through the air gap and one air flow through the pole gaps.

BRIEF DESCRIPTION OF THE DRAWINGS:

The invention will be described in more detail in the following with reference to
20 the accompanying drawings in which

Figure 1 shows a schematic axial section through a rotating electric machine with a one-way air-cooled rotor in accordance with the present invention,

25

Figure 2 shows a partial radial section through a rotor provided with a device in accordance with the present invention,

Figure 3 shows a partial axial section along the line A-A through a rotor pole according to Figure 2.

30

DESCRIPTION OF THE INVENTION:

Figure 1 shows a rotating electric machine 1 comprising a stator 2 with stator winding 3 which may consist of high-voltage cable. The machine 1 is provided
35 with a rotor 4 arranged on a machine shaft 6 journaled in a machine housing 5. The rotor 4 is also provided with a fan 8 having blades 7. A controlled air flow for

axial rotor cooling is indicated by arrows in the Figure. This also shows how the coil end parts of the machine are allowed to be cooled by the air flow. However, the invention is not limited to the embodiment shown in the drawing and according to a different embodiment the coil end parts can be cooled separately to avoid cooling one coil end with heated air. This can also be achieved by two-way axial cooling where each end of the rotor is provided with a fan blowing in air towards the middle of the rotor, the air then leaving through a radial air duct situated in the middle of the stator.

Figure 2 shows a partial radial section through the rotor 4 which has salient pole gaps 9 between each rotor pole 10. A field winding 11 is arranged around the rotor poles. A pole shoe 12 is arranged outermost on each rotor pole 10. The pole shoe 12 is provided along both sides with a bevelled edge surface 13. A cover member 14 is applied in the outer part of the pole gap 9, which seals between the adjacent edge surfaces of two pole shoes. In the embodiment with one-way cooling the cover member 14, which may be of metallic material or of plastic, is glued or screwed to the edge surfaces along the entire axial length of the rotor. In the embodiment with two-way cooling, on the other hand, the cover member is divided or perforated at the axial centre of the rotor so that the air can be deflected from its axial direction to a radial direction out through an air duct in the stator. As can also be seen in Figure 1 an air gap 15 exists between rotor 4 and stator 2.

In small machines cooled only by air, this air gap is used to blow air through for cooling both rotor and stator. In large machines, as in the present case with water-cooled stator, this is an uneconomical cooling method and the air flow through the air gap should therefore be as small as possible, enabling it to be used where it is better needed - in the present case to flow through the pole gaps and possibly also to cool the coil end parts at the same time.

According to Figure 3 at least one sealing ring 16 is permanently arranged on the periphery of the rotor 4 in order to minimize or avoid air flow in the gap 15. As is also clear from Figure 3, the sealing ring 16 is placed on one side of the rotor 4, in the present case on the air-inlet side of the machine. This prevents air from flowing into the air gap 15 between rotor 4 and stator 2.

Another advantageous embodiment of the present invention is, in corresponding manner, to provide the stator with a permanently arranged sealing ring in the air gap between stator and rotor.

- 5 The invention is not limited to the embodiments shown. Several modifications are feasible within the scope of the invention. The sealing ring, for instance, can be fitted in any axial position whatsoever on rotor or stator. Further, several sealing rings can be fitted either on the rotor or the stator. A number of sealing rings may also be fitted on the rotor and a number on the stator, to cooperate as a labyrinth
- 10 seal in order to minimize the air flow between rotor and stator.

CLAIMS

1. A rotating electric machine (1) having a stator (2) provided with windings and a rotor (4) provided with field windings and with salient poles (10) forming pole gaps (9) between the pole shoes (12) of the poles (10), which rotor (4) is arranged to be cooled by air flowing axially through the pole gaps (9) of the rotor (4), characterized in that each pole gap (9) between the pole shoes (12) is covered by at least one covering member (14) and that the air gap (15) is equipped with an air choke (16) to limit axial air flow.
2. A machine as claimed in claim 1, characterized in that the rotor (4) is provided with at least one fixed sealing ring (16) arranged around the rotor (4) in the air gap (15) between stator (2) and rotor (4).
3. A machine as claimed in claim 1, characterized in that the stator (2) is provided with at least one internally fixed sealing ring (16) arranged around the stator (2) in the air gap (15) between stator (2) and rotor (4).
4. A machine as claimed in either of claims 2-3, characterized in that the sealing ring (16) is placed on the air-inlet side of the machine (1).
5. A machine as claimed in any of the preceding claims, characterized in that the cooling air flow is arranged to be achieved by means of a fan (8) connected to the rotor (4).
6. A machine as claimed in any of the preceding claims, characterized in that the cover member (14) is divided or perforated at the axial centre of the rotor (4) so that the air can be deflected from its axial direction to a radial direction out through an air duct in the stator (2).
7. A machine according to any of the preceding claims, characterized in that the stator winding (3) consists of high-voltage cable.

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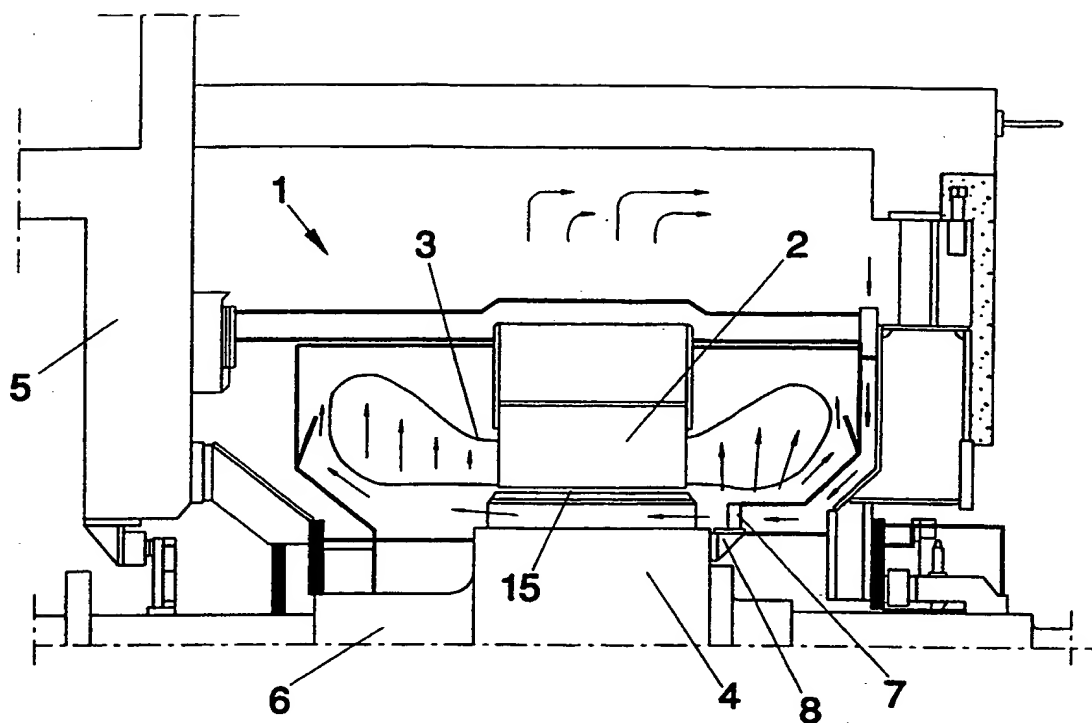


Fig 1

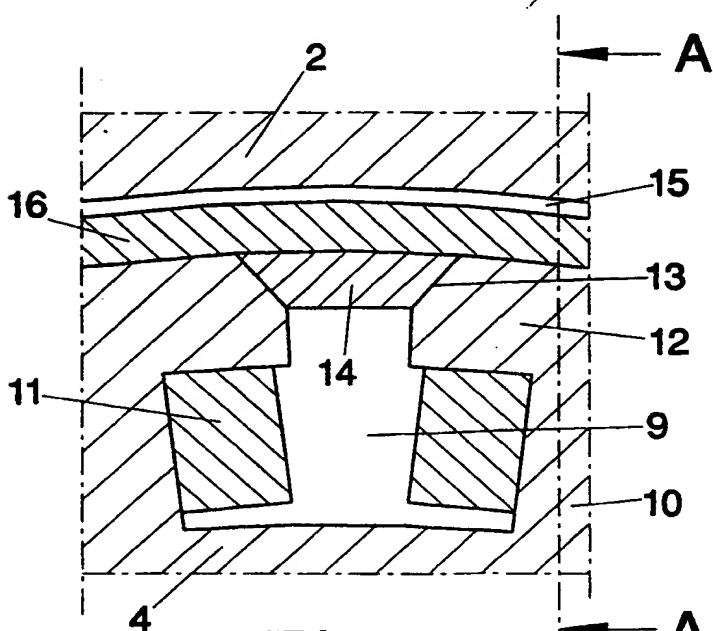


Fig 2

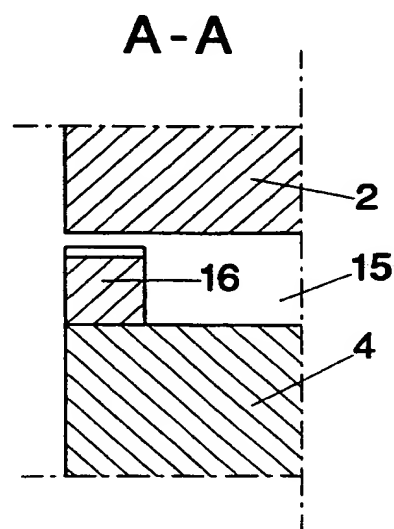


Fig 3

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/01841

A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: H02K 9/00 According to International Patent Classification (IPC) or to both national classification and IPC		
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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 3157806 A (E. WIEDEMANN ET AL.), 3 November 1960 (03.11.60), see the whole document --	1
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A	US 3968388 A (D. LAMBRECHT ET AL.), 6 July 1976 (06.07.76), abstract --	2-3
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

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03/02/98

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